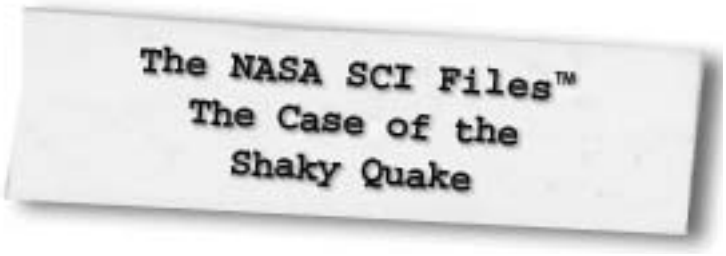



# Segment 3

As the tree house detectives continue their investigation for the answer to the mysterious tremor, they decide to contact Ms. Andrea Donnellan at NASA's Jet Propulsion Laboratory (JPL) where she explains how the Global Positioning System (GPS) uses satellites to accurately measure any movement in the Earth's crust. Not convinced that it was an earthquake, the detectives brainstorm for other possible solutions but continue their research on earthquakes as Jacob and R.J. meet Dr. D at the California Academy of Sciences in San Francisco, California. There Dr. D explains how earthquakes produce various types of waves and how these waves travel through the Earth's crust. Dr. Carol Tang joins them and explains how earthquakes are measured and how they destroy buildings. Dr. D, Dr. Tang, R.J., and Jacob all hang on for a wild ride as they "experience" an earthquake in the earthquake room at the Academy.

# Objectives

The students will

- observe that waves are created when energy is released.
- demonstrate how primary and secondary waves travel.
- understand how soil can liquefy during earthquakes to cause destruction.
- learn the various scales used to measure earthquakes.
- use real time data to locate and analyze earthquakes

# Vocabulary

**blind fault—**a break in the crust that does not break through to the surface

**epicenter—**the point on Earth's surface directly above an earthquake's focus

**focus—**in an earthquake, the point in Earth's interior where movement releases energy to cause an earthquake

**Global Positioning System (GPS)—**satellite navigation system consisting of 24 satellites

**moment magnitude scale—**a scale used by scientists to measure the energy released by an earthquake

**primary (P) waves—**waves of energy, released during an earthquake that travel the fastest through Earth by compressing particles in rocks in the same direction the wave is traveling

**Richter scale—**describes how much energy is released by an earthquake

**secondary (S) waves—**waves of energy, released during an earthquake, that travel through the Earth by moving particles in rocks at right angles to the direction the wave is traveling

**slip rate—**the rate at which two sides of a fault are moving past each other; typically measured in millimeters per year

**surface wave—**waves of energy, released during an earthquake, that reach Earth's surface and travel outward from the epicenter in all directions

# Video Component

## Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich the existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

## Before Viewing

1. Prior to viewing Segment 3 of *The Case of the Shaky Quake*, discuss the previous segment to review the problem and what the tree house detectives have learned thus far. Download a copy of the Problem Board from the NASA SCI Files™ web site and have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 2 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have been dispelled during Segment 2. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Focus Questions - Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program to answer the questions. An icon will appear when the answer is near.
5. What's Up? Questions - Questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. These questions can be printed from the web site ahead of time for students to copy into their science journals.

## View Segment 3 of the Video

For optimal educational benefit, view *The Case of the Shaky Quake* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

## After Viewing

1. Have students reflect on the "What's Up?" questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what new information they have learned about the layers of the Earth, fossils, and plate movement. Organize the information, place it on the Problem Board, and determine if any of the students' questions from Segment 2 were answered.
4. Decide what additional information is needed for the tree house detectives to determine what caused the tremor. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.

### Careers

geophysical technician
museum worker
structural engineer

5. Choose activities from the educator guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
6. If time did not permit you to begin the web activity at the conclusion of Segments 1 or 2, refer to number 6 under "After Viewing" on page 15 and begin the Problem-Based Learning activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, Problem-Based Learning activity:

   **Research Rack** - books, internet sites, and research tools

   **Problem-Solving Tools** - tools and strategies to help guide the problem-solving process.

   **Dr. D's Lab** - interactive activities and simulations

   **Media Zone** - interviews with experts from this segment

   **Expert's Corner** - listing of Ask-An-Expert sites and biographies of experts featured in the broadcast
7. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon, as suggested on the PBL Facilitator Prompting Questions instructional tool found in the educator's area of the web site.
8. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. Visit the Research Rack in the tree house, the online PBL investigation main menu section "Problem-Solving Tools," and the "Tools" section of the educator's area for more assessment ideas and tools.

# Resources

## Books

Levy, Matthys and Salvidori, Mario: *Earthquake Games: Earthquakes and Volcanoes Explained By 32 Games and Experiments.* M.K. McElderry Books, 1997, ISBN 0689813678.

Vandeave, Janice Pratt: *Janice VanCleave's Earthquakes: Mind Boggling Experiments You can Turn Into Science Fair Projects*. John Wiley & Sons, Inc., 1993, ISBN 0471571075.

Walker, Bryce S: *Earthquake*. Time-Life Books, 1982, ISBN 0809443007.

## Web Sites

**Exploratorium: The Great Shake—San Francisco, 1906**
Take a virtual walk through the aftermath of the great quake that took place in San Francisco in 1906 while reading descriptive accounts of the day.
*http://www.exploratorium.edu/faultline/1906/index.html*

**Kid Zone: A Quiz, Puzzle, and Answers To Your Common Earthquake Questions**
Take a quiz, try a crossword puzzle or word search, make your own, or simply find answers to your questions about earthquakes.
*http://www.abag.ca.gov/bayarea/eqmaps/kids.html*

**Liquefaction**
Learn how soil can act like a liquid. This site features photos and movie clips of liquefaction as it happened.
*http://www.cen.bris.ac.uk/civil/students/eqteach97/geo2.htm*

# Activities and Worksheets

In the Guide



On the Web

**Earthquake, Earthquake, Read All About It!**
Learn about the various scales that scientists use to measure earthquakes.

**Earthquake Analysis**
Use real time data to locate and analyze earthquakes.

# Waves in Action

## Purpose

To observe waves created by a release of energy

## Materials (per group)

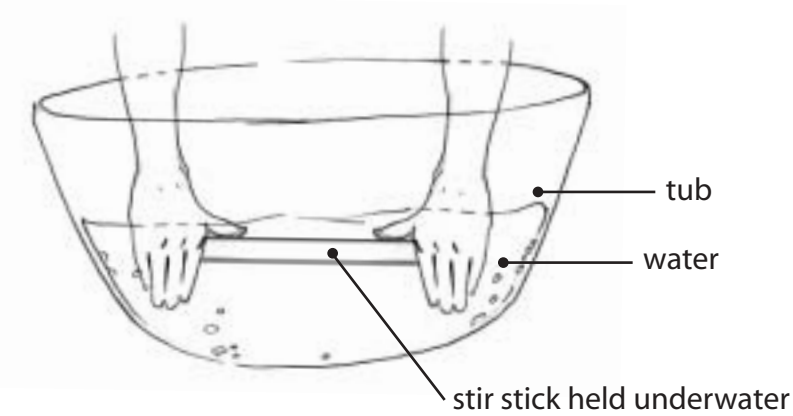
paint stir stick
plastic tub
water
science journal

## Procedure

1. Hold the stir stick firmly in one hand and use the other hand to apply pressure on the stirrer until it begins to bend. Be careful not to break the stick.
2. Observe the stirrer as you release the pressure.
3. Record your observations in your science journal.
4. Fill the plastic tub with water.
5. Place the stirrer completely under the water and hold it with one hand on each end. Be careful not to move and allow time for the water to become smooth.
6. Bend the stirrer slowly until it breaks.
7. Observe and record.

## Conclusion

1. What happened to the stirrer when you released the pressure in step 2? Explain.
2. What happened to the water when the stirrer was broken? Why?
3. Research the elastic rebound theory and give a report to the class.



# Have Wave Will Travel

## Purpose

To demonstrate how P and S waves travel

## Materials

Slinky®
science journal
meter stick

## Procedure

1. With your partner, stretch the Slinky® 2 meters.
2. To demonstrate a primary (P) wave, slowly pull the Slinky® toward you and then quickly push it away. See diagram 1.
3. Observe how the energy you released travels from you to your partner. Record your observations.
4. To demonstrate a secondary (S) wave, shake one end of the Slinky® up and down. See diagram 2.
5. Observe how the wave is traveling and record.
6. To demonstrate a horizontal secondary (S) wave, move the Slinky® from side to side. See diagram 3.
7. Observe and record.
8. To demonstrate a surface wave, push and pull the Slinky® at the same time that you move it up and down. Your hand should move in a circle. See diagram 4.

## Conclusion

1. Describe how the P and S waves differ.
2. According to Dr. D, which wave arrives first, second, last? Which wave does the most damage?
3. Conduct research to find out how waves are created and what happens to them as they travel away from the focus of an earthquake

## Extension

1. Use a Venn diagram to compare and contrast the various waves.
2. Use a Newton's Cradle or make your own with marbles attached to string to demonstrate the push-pull of P waves.

**Diagram 1**


**Diagram 2**

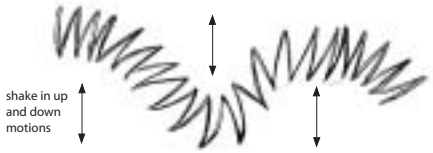
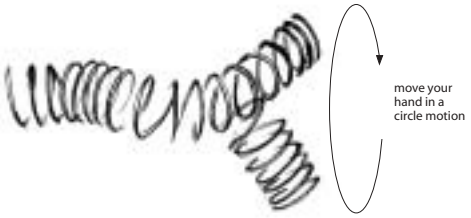



**Diagram 3**


**Diagram 4**



# Sweet Waves

## Purpose

To investigate the movement of waves

## Materials

- metal tray of prepared gelatin dessert
- dominoes
- sugar cubes
- plastic wrap
- rubber mallet
- science journal

## Procedure

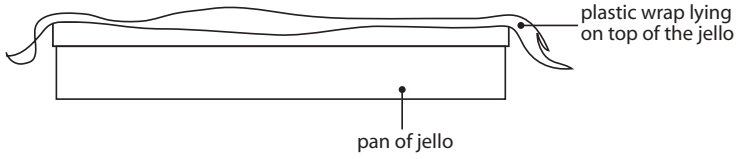
1. Take the pan of prepared gelatin and place it on a flat surface.
2. The gelatin represents the crust of the Earth. Predict what would happen to the crust if an "earthquake" were to occur and record in your science journal.
3. Using a rubber mallet, create an earthquake by lightly tapping the side of the pan.
4. Observe and record the results in your science journal.
5. Tap the side of the pan harder and observe and record.
6. Place the plastic wrap on top of the gelatin.
7. Use the dominoes and sugar cubes to create buildings and other structures.
8. Predict what will happen when you strike the pan.
9. Now hit the side of the pan again and record the results.
10. Experiment with the placement and arrangement of the buildings and the amount of force you use to hit the side of the pan in order to change the results.
11. Once you have completed the activity, remove the plastic wrap and enjoy the edible crust.

## Conclusion

1. What happened when you tapped the pan harder?
2. What happened to the buildings on the surface? Why?
3. How could you make your buildings sturdier, so that they won't fall over?

## Extension

1. Place popcorn kernels on top of a cereal box and gently tap the side of the box for five seconds. Stop and count the number of kernels that fell off. Repeat, tapping the box for ten seconds. Discuss the results.



# The Foolish Man Built His House Upon the Sand

## Materials

heavy plastic tub
sand
water
brick
rubber mallet
science journal

## Background

Liquefaction is a physical process that can take place during earthquakes and often leads to ground failure. Liquefaction is the term used to describe when a solid (in this case a soil) begins to act as a fluid. When dry sand is subjected to a force such as earthquake waves, the soil will become packed more tightly together, reducing its volume. The strength of the soil depends upon the friction between the sand particles. When sand contains water in the spaces between the sand particles, the strength of the soil is reduced. What has essentially happened is that the increased pressure of the water filling the spaces has reduced the friction between the soil particles. Since sand's shear strength is entirely dependent upon the internal friction (between the particles), the soil's strength is reduced or, in some cases, completely lost. When all the stress has been transferred to the water and maintained for a period of time, the soil behaves as a liquid. Since the soil is acting as a liquid, structures resting on it will sink or tilt. The amount they move will depend on how viscous the liquefied soil is and how long it remains liquefied (as well as other factors). If you have stepped on a piece of ground only to sink down past your foot, you have experienced liquefaction!

## Purpose

To understand liquefaction and how it can cause the ground to become unstable during an earthquake

## Procedure

1. Fill the tub 5 cm from the top with sand and spread it to form a flat, even surface.
2. Set the brick vertically on the sand surface and push it down to slightly anchor it.
3. Using the mallet, very gently tap the sides of the tub several times to create an "earthquake."
4. Observe what happens to the sand and the brick. Record in your science journal.
5. Slowly add water to the tub until the water just appears at the surface. Let the water be absorbed for a few minutes.
6. Using the mallet, repeat tapping the sides of the tub and observe what happens to the sand and the brick. Record your observations.

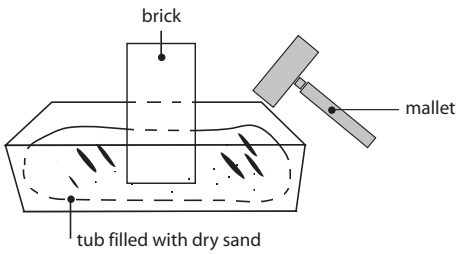



**Diagram 1**

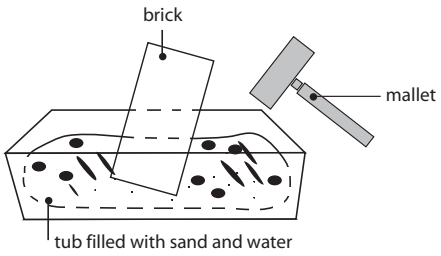



**Diagram 2**

# The Foolish Man...(continued)

## Conclusion

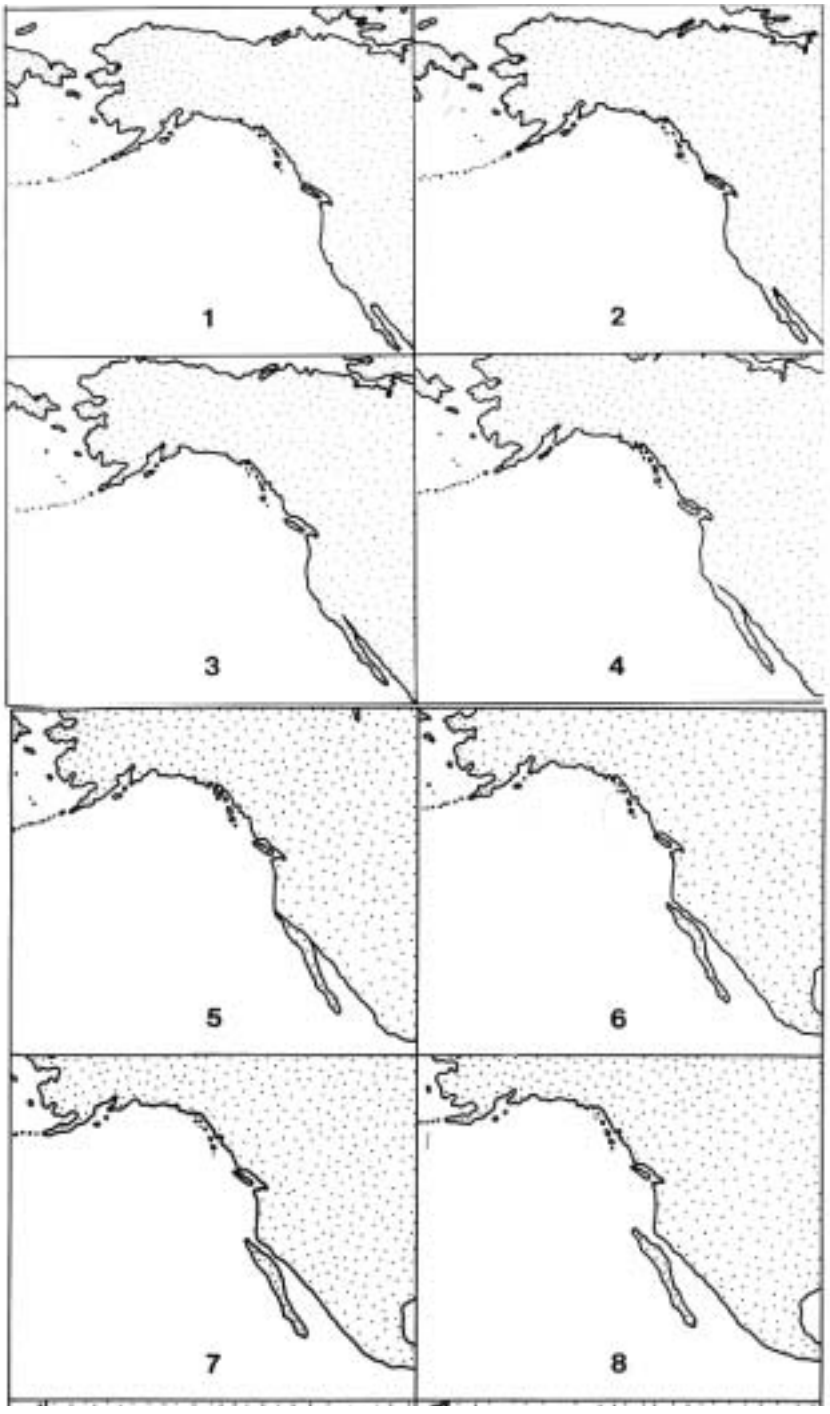
1. Explain what happened to the sand and the brick when the tub was tapped before adding the water?
2. Explain what happened to the sand and the brick after the water was added and the tub was tapped?
3. During an earthquake, what could happen to buildings on top of soil that was liquefied?

## Extension

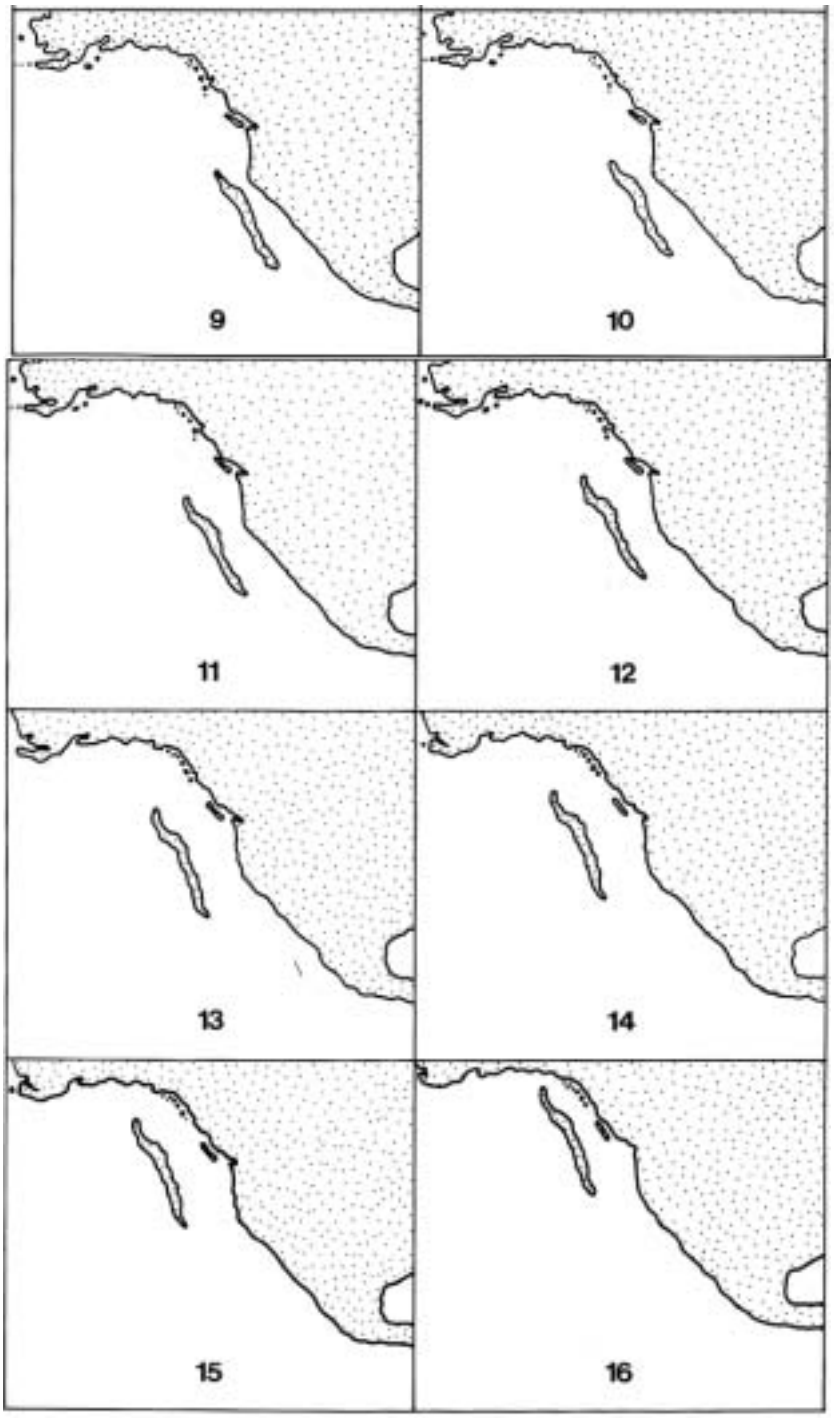
1. To help students understand that there is space between molecules, fill a jar full of marbles and ask the students if the jar is full. Add salt or sugar to the jar until "full" and repeat the question. Add water to the jar and repeat the question. Explain to students that even when things look tightly packed together, there is still space between molecules.
2. Read the following scenario and have each student take the role of a seismic engineer. Scenario: In the city of Kwiksands, the city council has decided to build a business park on several acres of land. As a seismic engineer hired to check out the land for safety measures, you have discovered that the ground in that area is highly permeated with water. You are responsible for writing a letter to the city council advising them of your findings and informing them of the risks involved in building on that land.
3. Research the threat of liquefaction to the San Francisco Bay area of California and other areas and create a report to share with the class.

# California On the Move

Color the water light blue and the land brown in each of these pictures; then cut along the lines and assemble them into a flip book, with number 1 on top. Flip the pages to see a time-lapse movie of 50 million years of California's future.



# California On the Move (continued)



# Answer Key

**Waves in Action**

1. When the pressure on the stirrer was released in step 2, the stirrer returned to its approximate original shape. When the stirrer was bent, energy was transferred from your hands to the stirrer. Once the pressure was released, the stirrer was able to return to its original position because the wood was flexible.
2. When the stirrer was bent, energy was transferred from your hands to the stirrer. The stirrer kept storing this energy until it broke. Once broken the energy was transferred to the water. Waves radiated from the breaking point of the stirrer, causing the water to become unsettled.
3. Reports will vary. This buildup and release of energy in the plates of the Earth is the foundation of the Elastic Rebound Theory.

**Have Wave Will Travel**

1. The P wave traveled back and forth along the same direction it was traveling. These are known as longitudinal or compression waves. With the S wave, the slinky moved up and down perpendicular to the direction that the wave was traveling. The horizontal S wave moved horizontally but also at right angles to the direction of the progressing wave.
2. The fastest moving wave is the P wave, then the S wave, and last the surface wave. Surface waves do the most damage.
3. An earthquake begins when stress on large blocks or rock becomes greater than the strength of the rock. The rock fractures, releasing vast amounts of energy. This energy is carried outward in all directions by various seismic waves, some of which can reach the opposite side of the Earth in about twenty minutes. The further the waves travel from the focus of the earthquake, the weaker they become.

**Sweet Waves**

1. The harder you tap the pan, the larger the waves.
2. The buildings and structures were knocked over and destroyed as you tapped the side of the pan. The larger the wave created, the more damage done. The waves made the structures move up and down and side-to-side making them unstable and imbalanced until they fell.
3. Answers will vary but might include that the structures need to be reinforced to withstand the motion created by the waves.

**The Foolish Man Built His House Upon the Sand**

1. The brick may have moved slightly in the earthquake, but the sand was strong enough to support the brick.
2. During this earthquake, the brick slowly sank into the moistened sand and probably tilted or toppled over.
3. The brick behaved like that of a tall building on mushy soil. When the soil liquefies, it cannot support the mass of the building and it simply falls down or collapses.

**California On the Move**

1. Answers will vary.
2. Answers will vary.
3. California experiences a lot of earthquakes because it is located on two plates sliding past one another. The sliding creates a lot of friction and stress over time. Eventually, the stress is released and earthquakes occur.
4. Reports will vary.

**On the Web**

**Earthquake Analysis**

1-3. Answers will vary as the information on the web site changes daily. Encourage students to look for patterns and correlations as they analyze the data.